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16. Summary/Notes

The initial phase of a wheat survey program was completed with the execution of a photographic mission during the booting growth stage of wheat (Triticum aestivum L.). Three 20 km. by 40 km. target areas in Rio Grande do Sul were flown after cost/time saving changes in aircraft, oxygen requirements, geometric parameters and base of operations. A WILD RC-10 metric camera with WRATTEN filter was used to expose color IR film to produce 1:20,000 scale transparencies and semi-controlled mosaics for hectareage estimations and data integration with hardware for CCT analyses. A BANDEIRANTE EMB-110B1 equipped with Daedalus scanner will be flown on future missions.

17. Remarks

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PLANNING AND EXECUTION OF A PHOTOGRAPHIC MISSION OVER A WHEAT PRODUCING REGION IN RIO GRANDE DO SUL, BRAZIL

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ABSTRACT

The initial phase of a wheat survey program was completed with the execution of a photographic mission during the booting and heading growth stage of wheat (*Triticum aestivum L.*). Three 20 km. by 40 km. target areas in Rio Grande do Sul were flown after cost/time saving changes in aircraft, oxygen requirements, geometric parameters and base of operations. A WILD RC-10 metric camera with WRATTEN filter was used to expose color IR film to produce 1:20,000 scale transparencies and semi-controlled mosaics for hectareage estimations and data integration with hardware for CCT analyses. A BANDEIRANTE EMB-110B1 equipped with Daedalus scanner will be flown on future missions.

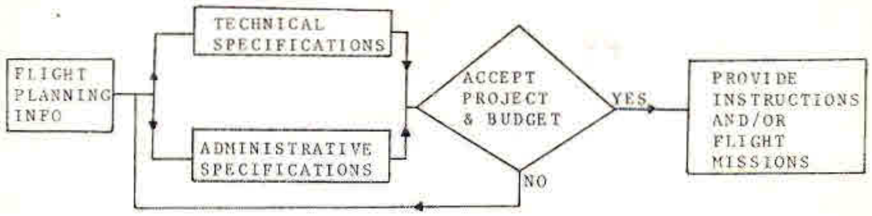
1. INTRODUCTION

The Institute for Space Research (INPE) has been active in airborne and orbital remote sensing for agriculture since the early use of a BANDEIRANTE 100 A in 1969 and the operation of the Cuiabá LANDSAT receiving station in 1973. This paper outlines the planning stages and flight specifications of a photographic mission conducted to collect base data for a wheat survey over Brazil's major producing regions. The objectives of the survey (PROJETO TRIGO) include, 1) hectareage measurements of wheat crop areas for production estimations, 2) spectral discrimination of healthy and infested wheat for the detection and defense against seasonal outbreaks, and, 3) integration of survey and meteorological data for regional yield forecasting. Much of our base data, compiled in semi-controlled mosaic format and computer cards will be used by various agencies for agricultural planning. Future work at INPE's Remote Sensing Department will involve phasing the base data into multispectral analyzer hardware to assist CCT analyses.

2. MISSION PLANNING

To initiate a mission involving the coordination of activities, from pre-flight preparation to final photographic product, we resolved to divide mission planning into two phases. This would ensure guidelines permitting for low costs and a satisfactory budget and for the conclusion of services within a pre-determined deadline.

As illustrated on the following page, the planning specifications were divided into "technical" and "administrative" parts. Mission responsibilities were subject to feedback after step by step feasibility assessments before a final decision was made to accept or reject the mission and/or budget.



2.1 MISSION SPECIFICATIONS

The technical specifications of the mission planning phase were itemized as follows:

1 - mission objective
2 - target area selection
3 - geometric parameters for aerial coverage
4 - radiometric parameters
5 - flight window
6 - photographic window
7 - selection of sensor
8 - cartographic materials.

The administrative priorities included:

9 - deadline for conclusion of underflight
10 - duration of field mission
11 - aircraft availability and selection
12 - base of operations
13 - final cost considerations.

Items 1 and 2 and 4 through 8 of the technical specifications were considered fixed, limiting changes to geometric parameters such as scale and forward overlap and sidelap. Among the administrative specifications, some flexibility was left in the choice of aircraft, quantity of film and base of operations, all of which affected final cost considerations.

Item 1 - mission objective - was to provide color IR coverage for the construction of a quantitative and qualitative data base for wheat crop assessments. Our objective was based on the assumption that a successful photographic mission could lead to a confident transfer to satellite surveying of wheat producing regions in the 1980's; thereby, freeing airborne operations for other relevant projects.

Item 2 - target area selection - had to meet certain criteria representative of wheat production under conditions of varying soil and climate regimes, seed varieties and farming techniques. The State of Rio Grande do Sul was targeted for coverage, being the largest wheat producer and historically the most subject to annual outbreaks of blight (eg. *Gibberella, Puccinia, Septoria*) and pests including lice and caterpillar. Three suitably distributed 20 km. by 40 km. target areas were selected on the "Planalto Media", a stepped table lands over 680 meters above sea level. Physiographically, the region is characterized by varying extremes of undulation, dark-red latosol soils on basaltic and granitic bases and remnant, isolated stands of *Araucaria* and mixed hardwoods.

Technologically, the region is highly mechanized, although non-irrigated, and organized through a system of cooperatives (seed, fertilizer, drying, storage and rural services).The complexity of wheat cultivation is intimated by the fact that more than forty seed varieties (HYV's and traditional) are recommended annually, largely based on the previous year's success.

The final selection and delimitation of the target areas on LANDSAT scenes of the previous growing season (May through October, path 206, row 22), was based on production and environmental criteria and the spectral distribution of wheat crop areas in relation to other land use types. The three areas selected and their respective coordinates on ARMY SERVICE MAPS (1:100,000) are as follows:

ARMY SERVICE SHEET			
SH-22-V-A-VI	AREA 1 - (Cruz Alta)	Latitude	$20^{\circ}30'S$ - $28^{\circ}45'S$
		Longitude	$53^{\circ}30'W$ - $54^{\circ}00'W$
SH-21-X-B-III	AREA 2 - (Santo Ângelo)	Latitude	$27^{\circ}55'S$ - $28^{\circ}20'S$
		Longitude	$54^{\circ}10'W$ - $54^{\circ}25'W$
SH-22-V-A-IV	AREA 3 - (Soledade)	Latitude	$28^{\circ}30'S$ - $28^{\circ}45'S$
		Longitude	$58^{\circ}30'W$ - $53^{\circ}00'W$

Also planned and executed was a low altitude, panoramic photographic pass over the National Center for Wheat Research (CNPTrigo) in Passo Fundo (45 km. northeast of Area 3).

Item 3 - geometric parameters - were initially assigned to a scale of 1:25,000 with a frontal overlap of 60% and sidelap of 30%. This margin of imagery superposition was considered optimal for spectral discrimination and interpretation, although some incompatibility with the IMAGE-100 analysis was to be expected.

Item 4 - radiometric parameters - were considered from the standpoint of film sensitivity, false color enhancement and reflectance characteristics of wheat crops and contrasting land use features. The film selected for exposures was KODAK AEROCHROME 2443 INFRARED type. Past experience has shown this film to be especially suitable for red exposure (rendition to green), which provides excellent contrast between sandy and latosol soils and green vegetative color (rendition to red). A WRATTEN filter 15+20 m + Av.2.3 was selected for blue absorption. The film and filter combination used, with an aerial exposure of 1/200 at f/5.6, has shown good results for the processing of color IR transparencies.

Item 5 - flight window - was determined by the stage of wheat growth and its susceptibility to blight, in spite of overcast conditions which predominate the season selected (Fig.1). A window between August 17 and September 16, 1979 was decided upon: ground cover is complete, wheat is in the booting and heading stages and susceptible to various seed and soil transmitted pests and diseases.

Item 6 - photographic window - was set for an interval between an 8:45 a.m. and 15:45 p.m. solar elevation of 30°. Photographic "hot spots" were not considered to be accentuated during the six hour window and topographic differences are not sufficiently extreme in the target areas to produce shadow effects.

Item 7 - selection of sensor - was contingent upon the decision to use infrared film. A WILD RC-10 metric camera with 152 mm focal length and infrared filters was chosen for the mission.

Item 8 - cartographic materials - was a general category for the inclusion of all available visual aids used for the project's target area selection, mission logistics and navigation. These aids included LANDSAT imagery, Army Service Topographic sheets at scales of 1:100,000 and 1:50,000, state highway, hydrology and land use maps (1:750,000), and Município survey maps. The most useful materials were found to be topographic sheets, although dated, and LANDSAT-2 and LANDSAT-C MSS positives (1:250,000).

Among the administrative specifications, Item 9 - mission deadline - was set for September 16, a decision based on mission costs and wheat growth development information provided by the National Wheat Research Center (CNPTrigo). It was decided that beyond this date, the flight crew would proceed to two alternative target areas, irregardless of whether the priority areas had been flown.

Item 10 - duration of field mission - was based on a timetable that would allow for, 1) the administering of a statistically significant number of field interviews, and, 2) the systematic designation of imagery check points and the running of a transect along several hundred kilometers of dirt roads. Area 3 (Soledade) was selected for intensive study owing to its proximity to personnel from CNPTrigo in Passo Fundo. A sixteen day field calendar scheduled for the period September 1 to September 16 was found to be adequate to throughly travel one 20 km. x 40 km. area and cover by transect the remaining two areas.

Item 11 - aircraft availability and selection - was considered in terms of costs, maintenance and the following specifications:

1) flight stability
2) oxygen consumption
3) frontal, lateral and vertical visibility
4) service ceiling
5) empty and fully equipped weight
6) comfort.

As shown, two aircraft were considered for the mission, both presenting excellent operating specifications for the mission requirements.

AERIAL SURVEY CRAFT	WING CONFIGURATION	NUMBER OF SEATS	PRESSUR-IZATION	HORIZONTAL SPEED	ENDUR-ANCE	HOURS AVAILABLE
NAVAJO EMB820	low wing	4	no	350 km/h	05:30	30
AERO COMMANDER 500S	high wing	3	no	310 km/h	05:30	100

While the AERO COMMANDER had more hours available, it was underflight revision leaving the NAVAJO EMB 820 which had thirty available hours and installed metric camera.

Item 12 - base of operations - was initially selected at the Santa Maria airport, which has provisions for oxygen, refuelling and radio navigation. For logistical reasons (the airport is located outside of the target areas), this base was rejected for a smaller airfield in Santo Ângelo (Area 3) which does not furnish oxygen. This problem was resolved by reducing our flight altitude and increasing our photographic scale.

Item 13 - final cost considerations - was a critical factor in determining the viability of the project, especially in view of spiralling costs for aviation fuel, field support and film processing. Several mission specifications were altered in the final planning stages to reduce costs. These included a change in aircraft (Item 11), the base of operations (Item 12) and geometric parameters such as flying height, photographic scale and overlap (Item 3). Photographic scale affects costs in relation to flying height, distance from base of operations and number of photos required to satisfy the mission's objectives. To execute a flight line at a scale of 1:25,000 would have required a flight ceiling of 4,206 meters above sea level and the use of oxygen masks or a pressurized aircraft. Moreover, the Santa Maria airport facilities, which service oxygen needs is fifteen to thirty minutes flight time depending on the target area. The change of airfield to Santo Ângelo and reduction of altitude to 3,350 meters above sea level to dispense with oxygen needs was considered cost effective when figured over the duration of the flight window. An accompanying scale change to 1:20,000 and reduction of frontal overlap from 60% to 30% kept the total number of required scenes per area at 91 despite a flight line increase from five to seven as illustrated below.

SCALE	OVERLAP	SIDELAP	NO. PHOTOS	NO. STRIPS	NO. PHOTOS PER STRIP
1:25,000	60% ADVANCE 2,300m.	30% ADVANCE 4,025m.	90	5	18
SCALE	OVERLAP	SIDELAP	NO. PHOTOS	NO. STRIPS	NO. PHOTOS PER STRIP
1:20,000	30% ADVANCE 3,220m.	30% ADVANCE 3,220m.	91	7	13

2.2 ADDITIONAL FLIGHT PARAMETERS

Other vital flight specifications included flying height above ground, flight direction and navigation.

Following the scale adjustment, the flying height above ground, *Z*, was calculated by averaging lowest and highest elevations in the region. This method was found to be acceptable for gently undulating topography characteristic of the target areas.

The direction of flight was determined according to the lengthwise orientations of the test areas with no consideration given to topography nor prevailing winds. To economize time and flight distance, areas 1 and 3 were flown west to east to west and area 2 was covered in the direction north to south to north. After each final pass, an additional strip was flown over any irregularities or gaps in the sidelapping. This test strip was designated by the number of the anomalous strip plus a letter *T* for laboratory identification. The presence of a test strip at the end of the exposed film roll proved to be a time saving aid in processing and quality control.

Lacking instrumentation for photographic navigation, we relied on visual means, using topographic charts at the 1:100,000 scale. Both pilots selected for the mission were experienced visual navigators, which eliminated extra time and costs for pre-coverage terrain recognition. Two other stipulations were: to avoid the use of more than one topographic map at one time and to avoid a gap between flight lines because of a misjudged entrance. As shown in Figure 2 entrance was executed after a lateral recognition pass. The aircraft was set on automatic pilot during photographic exposure and flown manually to execute a one minute re-entry pattern.

3. MISSION RESULTS

The aircraft landed in Santo Ângelo on October 26. Eight consecutive days of intermittent rain grounded the mission through September 1. The following day clear skies permitted for the coverage of test areas 1 and 2. The latter was flown in the morning when strong turbulence required that a test strip be flown between lines 4 and 5. Turbulence and cumulous clouds grounded the plane on September 3 after two aborted attempts to photograph area 3.On the morning of September 4, area 3 was covered and a later afternoon panoramic pass over the CNPTrigo experimental station was executed en route to alternative target areas, one in Paranã State and one in São Paulo State.